
48 V ELVDC वितरण प्रणाली — दिशा निर्देश

48 V ELVDC Distribution System — Guidelines

ICS 29.260.20

© BIS 2017



भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली-110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.org.in www.standardsbis.in

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards after the draft finalised by the Low Voltage d.c. Distribution Systems Sectional Committee had been approved by the Electrotechnical Division Council.

Indian Electricity Act, 2003 and the *Electricity (Safety) Regulations, 2010* framed thereunder together with National Electric Code, SP 30 govern the electrical installation work in buildings in this country. Indian Standard IS 732 : 1989 'Code of Practice for Electrical Wiring Installations' governs the practice of installation of electrical wiring in buildings.

Solar power has established itself as a renewable energy source capable of achieving grid-scale parity. The cost per watt of solar modules is decreasing steadily year on year coupled with decreasing costs of storage per kilowatt hour it is now possible to have entire homes powered only with solar energy with reasonable investment.

Solar power is inherently d.c. and this has led to a growing interest in appliances that work directly out of d.c.. Almost all electronics work out of d.c. voltages and electronic appliances have a power conversion section that performs an a.c. - d.c. conversion for powering down-stream electronic sections.

With improvements in technology, the emphasis is on energy efficiency. In lighting, LED lamps are being widely used and are powered by d.c. . Motors consume a large portion of all electrical power generated and in view of robustness and size, many applications are witnessing a shift to permanent magnet machines. Efficient operation of these machines require d.c. voltage availability. Household machinery applications are also witnessing this trend. It is now possible to replace conventional a.c. appliances by these systems and operate them therefore directly from d.c. power. This enables better system efficiencies than conventional a.c. operated systems. It is therefore advantageous both from an energy efficiency perspective and from economics perspective to have solar powered homes working directly from an appropriate d.c. voltage instead of converting from d.c. to a.c. for powering electrical appliances.

Since energy efficiency and adoption of renewables is crucial to bridge the demand-supply gap in developing economies, there is a greatly felt need for a set of guidelines for d.c. distribution for residential applications. It is envisaged that these guidelines will also help to promote adoption of solar in a larger scale resulting in uptake of renewables, distributed power generation and demand management. The guidelines should also address safety and proven engineering practices. The guidelines should recommend a d.c. voltage for low voltage distribution similar to the use of a fixed distribution voltage that is adopted (actual voltage varies with country) for residential a.c. distribution. The recommended d.c. voltage for distribution should be compliant with the d.c. primary voltages that are defined in IEC 60038 : 2009 'IEC Standard voltages' as shown in Table 1.

Considering safety and energy efficiency as foremost priorities, a primary d.c. voltage range that is sufficiently safe needs to be chosen. Since this standard is likely to serve the needs of those communities that are not grid-aware, the possibility of electric injuries should be minimised even in the case of exposure due to direct contact. Further, the voltage should not be too low so that distribution losses are minimised. Since 60V is firmly established internationally as the upper limit for a Safety Extra Low Voltage circuit (SELV) (safe enough to touch directly under dry conditions), from a safety perspective, it is desirable that the d.c. voltage range be kept lesser than 60V in practice. Considering all these factors, 48V is chosen as the distribution voltage for d.c. considering both safety and distribution losses.

(Continued on third cover)

Indian Standard

48V ELVDC DISTRIBUTION SYSTEM — GUIDELINES

1 SCOPE

1.1 This standard covers the essential requirements for distribution of power from an extra low voltage 48 V d.c. power source. Power sources include, but are not limited to, interconnected or stand-alone batteries, solar photovoltaic systems, other distributed renewable generation systems, or generators. All sources of SELV and PELV as defined in IEC 60364-4-41:2005 'Low-voltage electrical installations — Part 4-41: Protection for safety — Protection against electric shock' are applicable but with a nominal voltage of 48V.

1.2 This standard is also applicable to locations where electrical utility service is not available and power is derived from single or multiple renewable energy sources. Safety isolation transformer or Class II power converters shall be used, if the voltage at any point in the power conversion system exceeds 60V in the process of 48V generation for feeding into the distribution system.

1.3 This standard is applicable to dwelling units and commercial units either single or multiple, guest rooms or guest suites of hotels, motels or similar occupancies, mobile homes, and in-building applications in general.

This code also covers essential requirements and precautions regarding wiring installations and equipment powered by d.c. sources for ensuring satisfactory and reliable service with the best possible energy efficiency. Installation includes all components involved in the supply of power from the source. Examples of Installation Wiring Components include distribution boxes, plugs and sockets, cables, power cords, etc.

1.4 Even though the power source is separated extra low voltage by definition, there are circumstances where safety needs to be addressed, especially during distribution. This standard also covers safety requirements for the installations.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication of this standard, the edition indicated are valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS/IEC No.</i>	<i>Title</i>
732 :1989	Code of Practice for electrical wiring installations

<i>IS/IEC No.</i>	<i>Title</i>
302-1 : 2008	Safety of household and similar electrical appliances : Part 1 General Requirements
13252 (Part 1) : 2010	Information technology equipment — Safety : Part 1 General Requirements
13703 (Part 1) : 1993	LV Fuses for voltages not exceeding 1000 V a.c. or 1500 V d.c.: Part 1 General requirements
IEC 60038 : 2009	IEC standard voltages
IEC 60269-2: 2013	Low-voltage fuses — Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) — Examples of standardized systems of fuses A to K
IEC 60364-1: 2005	Low-voltage electrical installations — Part 1: Fundamental principles, assessment of general characteristics, definitions
IEC 60364-4-41: 2005	Low-voltage electrical installations — Part 4-41: Protection for safety - Protection against electric shock
IEC 60364-4-43: 2008	Low-voltage electrical installations — Part 4-43: Protection for safety Protection against overcurrent
IEC 60364-4-44: 2008	Low-voltage electrical installations — Part 4-44: Protection for safety — Protection against voltage disturbances and electromagnetic disturbances
IEC 60364-4-53: 2008	Electrical installations of buildings — Part 5-53: Selection and erection of electrical equipment — Isolation, switching and control
IEC 60445 : 2017	Basic and safety principles for man-machine interface, marking and identification — Identification of equipment terminals, conductor terminations and conductors
IEC 61140 : 2016	Protection against electric shock — Common aspects for installation and equipment
IEC 61439-3: 2012	Low-voltage switchgear and controlgear assemblies — Part 3: Distribution boards intended to be operated by ordinary persons (DBO)
IEC 61643-21: 2000	Low voltage surge protective devices — Part 21: Surge protective

<i>IS/IEC No.</i>	<i>Title</i>
	devices connected to telecommunications and signalling networks — Performance requirements and testing methods
IEC TS 62257-2 : 2015	Recommendations for renewable energy and hybrid systems for rural electrification — Part 2: From requirements to a range of electrification systems
IEC TS 62257-7-1 : 2010	Recommendations for small renewable energy and hybrid systems for rural electrification — Part 7-1: Generators — Photovoltaic generators
IEC TS 62257-8-1 : 2007	Recommendations for small renewable energy and hybrid systems for rural electrification — Part 8-1: Selection of batteries and battery management systems for stand-alone electrification systems — Specific case of automotive flooded lead-acid batteries available in developing countries

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Rated Voltage — Value of voltage used for specification purposes, established for a specified set of operating conditions of a component, device, equipment or system.

3.2 Rated Voltage Range — Supply voltage range as declared by the manufacturer, expressed by its lower and upper rated voltages

3.3 Rated Current — Value of current used for specification purposes, established for a specified set of operating conditions of a component, device, equipment or system.

3.4 Class II Equipment — Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation are provided, there being no reliance on protective earthing or reliance upon installation conditions

3.5 Branch Circuit — The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s) or terminations consisting of two ungrounded conductors with voltage between them

3.6 Feeder — All circuit conductors between the service equipment if any, the source of a separately derived system if any, or other power supply source and the final branch-circuit overcurrent device.

3.7 Enclosure — Part of the equipment that provides some degree of safety from fire, injury from mechanical or physical hazards.

3.8 Functional Insulation — Insulation that is necessary only for the correct functioning of the equipment.

NOTE — Functional insulation by definition does not protect against electric shock. It may, however, reduce the likelihood of ignition and fire.

3.9 Basic Insulation — Insulation to provide basic protection against electric shock.

3.10 Double Insulation — Insulation comprising both basic insulation and supplementary insulation.

3.11 Working Voltage — Highest voltage to which the insulation or the component under consideration is, or can be, subjected, when the equipment is operating under conditions defined as being normal use.

3.12 Clearance — Shortest distance between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured through air.

3.13 Creepage Distance — Shortest path between two conductive parts, or between a conductive part and the surface of the equipment, measured along the surface of the insulation.

3.14 Bounding Surface — Outer surface of the enclosure, considered as though metal foil were pressed into contact with accessible surfaces of insulating material.

3.15 Solid Insulation — Material that provides electrical insulation between two opposite surfaces, not along an outer surface.

3.16 Interconnecting Cable — Cable used to,

- a) electrically connect an accessory to an equipment;
- b) interconnect units in a system; or
- c) connect a unit to a LVDC distribution system.

3.17 Functional Earthing — Earthing of a point in equipment or in a system, which is necessary for a purpose other than safety.

3.18 Protective Earth (PE) — The earth point in the building installation.

3.19 Protective Earthing Conductor — Conductor in the building installation wiring, or in the power supply cord, connecting a main protective earthing terminal in the equipment to protective earth.

3.20 Protective Bonding Conductor — Conductor in the equipment, or a combination of conductive parts in the equipment, connecting a main protective earthing terminal to a part of the equipment that is required to be earthed for safety purposes.

3.21 Touch Current — Electric current through a human

body when it touches one or more accessible parts.

3.22 Protective Conductor Current — Protective current flowing through the protective earthing conductor under normal operating conditions.

3.23 Extra Low Voltage (ELV) — Voltage not exceeding the relevant voltage limit of band I specified in IEC 61140 ‘Protection against electric shock — Common aspects for installation and Equipment’

NOTE — In IEC 61140 band I is defined as not exceeding 50 V a.c. r.m.s. and 120 V d.c.

3.24 ELVDC Distribution System — The mains system for supply, and distribution of electric power powered from an ELVDC supply.

3.25 ELVDC Supply — Extra Low Voltage DC Supply

3.26 Safety Extra Low Voltage Circuit (SELV Circuit) — Secondary circuit that is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value.

NOTES

1 For commercial, industrial and telecommunication applications, the SELV voltage limits provided in IS 13252 (Part 1) are applicable. For household applications, the SELV voltage limits in IS 302-1 shall be used.

2 The limit values of voltages under normal operating conditions and single fault conditions (See **1.4.14** of IS 13252 (Part 1) are specified in **2.2** of IS 13252 (Part 1). See Table 1A of IS 13252 (Part 1).

3 This definition of a SELV circuit differs from the term ‘SELV system’ as used in IEC 61140.

3.27 Protective Extra-Low-Voltage (PELV) — Electrical circuit in which the voltage cannot exceed a.c. 30 V r.m.s., 42.4 V peak or d.c. 60 V in normal and single-fault condition, except earth faults in other circuits.

3.28 Functional Extra-Low Voltage Circuit (FELV) — Electrical circuit in which the voltage cannot exceed ELV used for functional purposes and having simple separation from LV.

NOTES

1 FELV does not fulfil the requirements for SELV (or PELV).

2 A FELV circuit is not safe to touch and may be connected to protective earth.

4 ARCHITECTURE

4.1 Systems Architecture

The systems architecture follows the T₂I Typology outlined in IEC TS 62257-2:2015 as given in Table 2. Table 2 excerpted from IEC 62257 shows the typology of decentralised electrification systems. TH system under consideration falls under T₂I classification.

4.1.1 The system will be a d.c. dispatch system. The system architecture follows a similar approach as that given in IEC 62257-2:2015 and shown below in Fig. 1 for reference, but with d.c. loads only and d.c. dispatch.

4.2 Electrification Systems Architecture

Isolated electrification system can be broken down into three parts:

- Energy production subsystem,
- Energy distribution subsystem, and
- Energy application subsystem.

4.2.1 Production Sub-system

The production system comprises equipment for,

- generating electricity, supplied by:

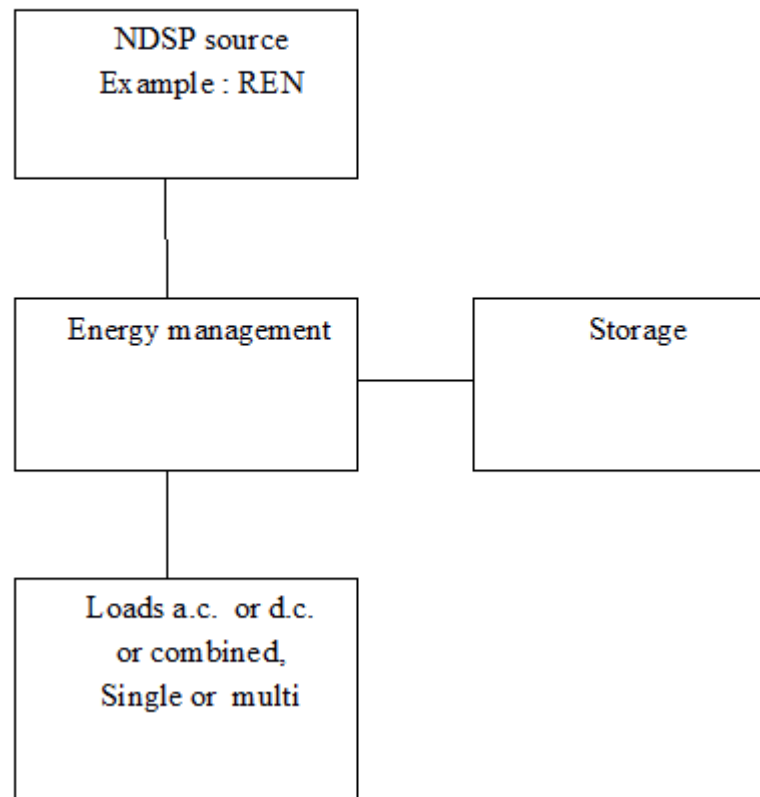
Table 2 Typology of Decentralized Electrification Systems
(Clause 4.1)

Sl No	Type of Generator		Classification of Associated Systems	
			Individual	Collective
(1)	(2)		(3)	(4)
i)	RE only, hybrid or not	No storage	T ₁ I	T ₁ C
ii)	RE, hybrid or not	Storage	T ₂ I	T ₂ C
iii)	RE, hybrid or not + Genset	No storage	T ₃ I	T ₃ C
iv)	RE, hybrid or not + Genset	Storage	T ₄ I	T ₄ C
v)	Genset only	No storage	T ₅ I	T ₅ C
vi)	Genset only	Storage	T ₆ I	T ₆ C

Notation principle: T_iI = individual system, type i ; T_jC = collective system, type j.

NOTE — “Storage” = storage of energy produced by one of the generators of the system and which can be reconverted “on demand” to electricity through the system.

T2



Key:

REN = Renewable source ; DSP = dispatchable; NDSP = non dispatchable

A source, generator, system is dispatchable if delivered power is available at any specified time.

A non dispatchable system is resource dependent; power might not be available at a specified time.

FIG. 1 GENERAL ARCHITECTURE OF A DISPATCHABLE SYSTEM WITH BOTH a.c. AND d.c. LOADS, AS DESCRIBED IN IEC 62257-2. THIS ARCHITECTURE FORM THE BASIS OF THE 48V DISTRIBUTION SYSTEM

- 1) Renewable energies such as the sun or wind, hydro, biomass (photovoltaic panels, wind-turbines), and
- 2) Fossil energy (gas-oil, motor spirit, kerosene) used as fuel for a generator set.
- b) storage of electric energy.
- c) conversion/transformation of energy by converters:
 - 1) d.c./d.c. convertors, and
 - 2) a.c./d.c. (rectifiers).
- d) protection of persons and goods by:
 - 1) Circuit-breakers,
 - 2) Fuses, and
 - 3) Earthing control devices.
- e) management of energy by:
 - 1) Basic regulators without energy management systems,
 - 2) Energy management systems (may include monitoring capability and remote access).

Certain parts of this equipment may be placed in boxes, cabinets or other edifices also comprising functions such as ventilation or alarm systems.

4.2.2 Distribution Sub-system and User or Application Sub-system or Demand Subsystem

Since the distribution is meant for in-building applications, the distribution and application sub-system can be combined and will consist of all the equipment using the energy,

- a) the user power supply box (including metering and safety equipment);
- b) the internal wiring installation; and

c) the receivers/loads operating on d.c.

4.2.3 Block Diagram of the General Architecture

Figure 2 shows a generic architecture for 48V d.c. distribution system feeding d.c. loads only. a.c. loads are excluded. d.c. loads may be connected directly to the 48V d.c. bus or through a d.c. / d.c. converter which interfaces with the 48V bus on the source side and d.c. loads on the other.

4.2.4 Installation Scenarios

4.2.4.1 Basic installation

Figure 3 shows a pure d.c. system where there is a single (distributed) d.c. source of energy (primarily PV). This is the basic installation where access to electricity is required in areas where grid has not penetrated. Grounding considerations need not be very elaborate resulting in a system with lesser costs without sacrificing protection

4.2.4.2 Grid-powered

a) Figure 4 shows a scenario where d.c. is derived from the grid. Such a system will have two

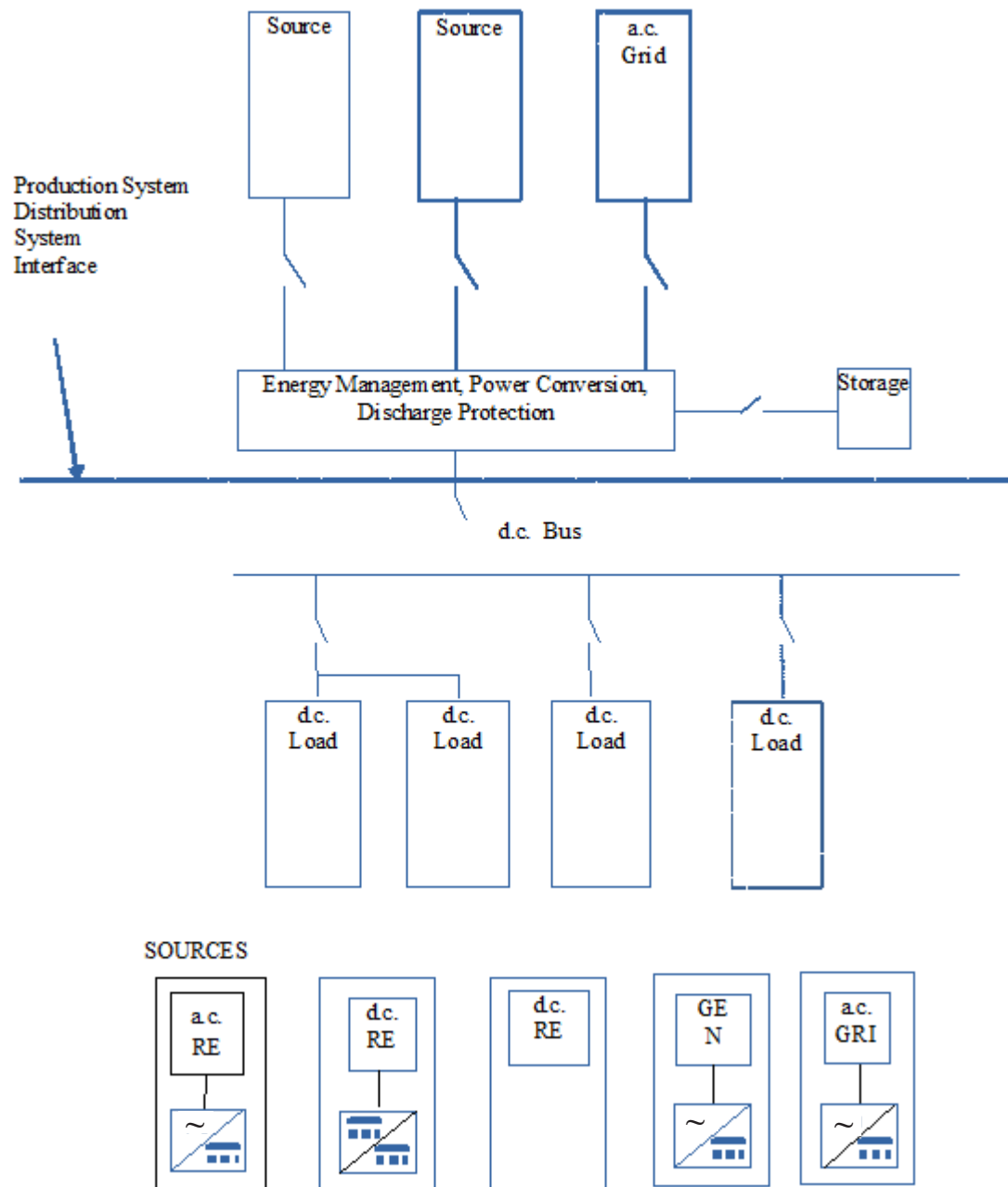


FIG. 2 GENERAL ARCHITECTURE FOR 48 V d.c. DISTRIBUTION SYSTEM FEEDING d.c. LOADS ONLY

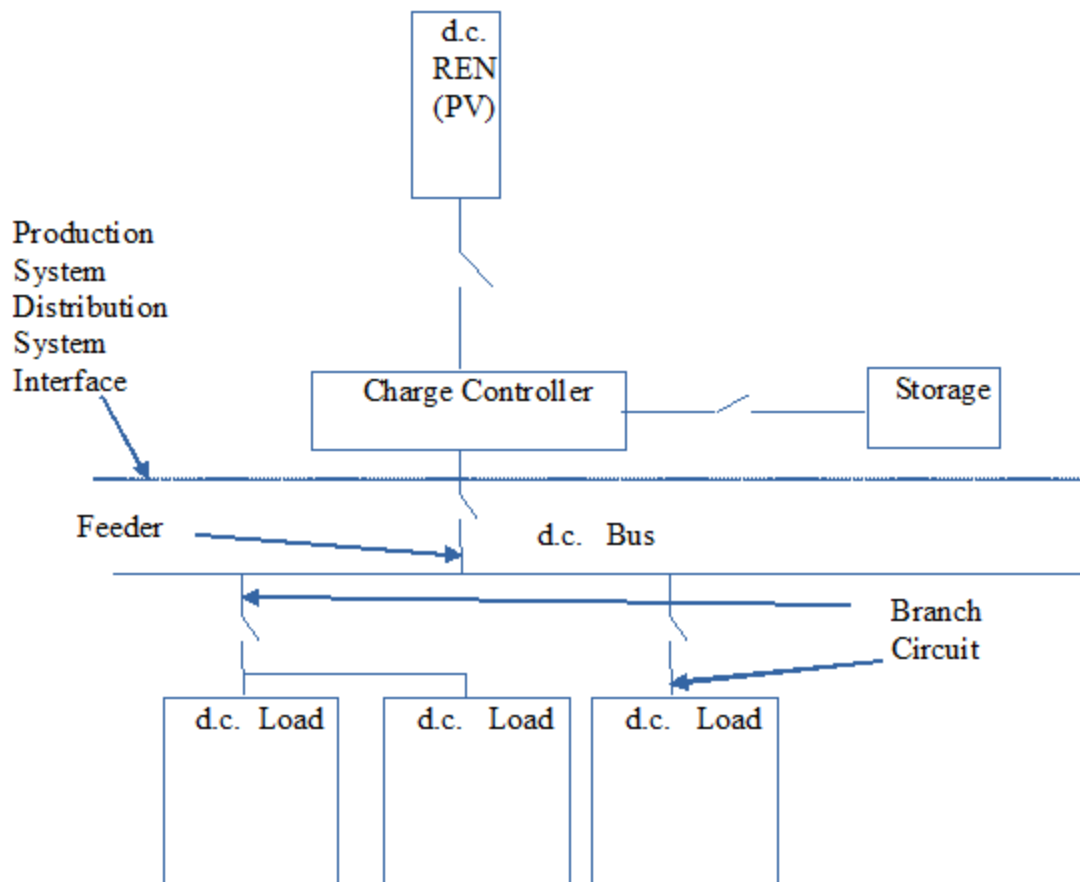


FIG. 3 PURE d.c. INSTALLATION (BASIC)

distribution systems — one for a.c. which is the normal grid distribution and the other one for d.c. which follows this standard.

Since there is storage present in the d.c. system, this architecture is useful in all locations including where grid power is unreliable. In addition, d.c. lights and d.c. fans may be used for lights and fans and powered from the d.c. distribution system. This can lead to lower electricity consumption due to higher efficiency and controllability of d.c. lights and d.c. fans.

- b) a.c. and d.c. distribution boxes shall be separate. a.c. and d.c. wiring shall be in different conduit.
- c) Where there is co-existence of a.c. and d.c., all applicable a.c. standards shall be followed in the a.c. section of the system.

4.2.4.3 Grid and d.c. renewable combination

- a) Figure 5 shows a scenario where a.c. and d.c. distribution systems co-exist, but d.c. is generated from renewable sources.
- b) a.c. and d.c. distribution boxes shall be separate. a.c. and d.c. wiring can be in the

same conduit subject to conditions.

4.3 Distribution Voltage and Current limits

The voltage at the distribution-side of the system shall be 48V nominal with a range of 43-55V. The rated current in a branch circuit shall be 5A.

4.4 Feeder Voltage and Current Limits

The voltage at the feeder-side of the system shall be 48V nominal. The maximum current in a feeder shall not exceed 40A rating.

5 WIRING AND PROTECTION

5.1 Installation and Wiring

Installation and Wiring shall be in accordance with IEC 60364-4-41.

5.2 Protection Against Electric Shock

Basic rules for protection against electric shock are given in IEC 61140 and IEC 60364-4-41:2005. Since the system is SELV, there is inherent protection from electric shock. Basic insulation is mandatory.

In the case of co-existence with a.c., separation

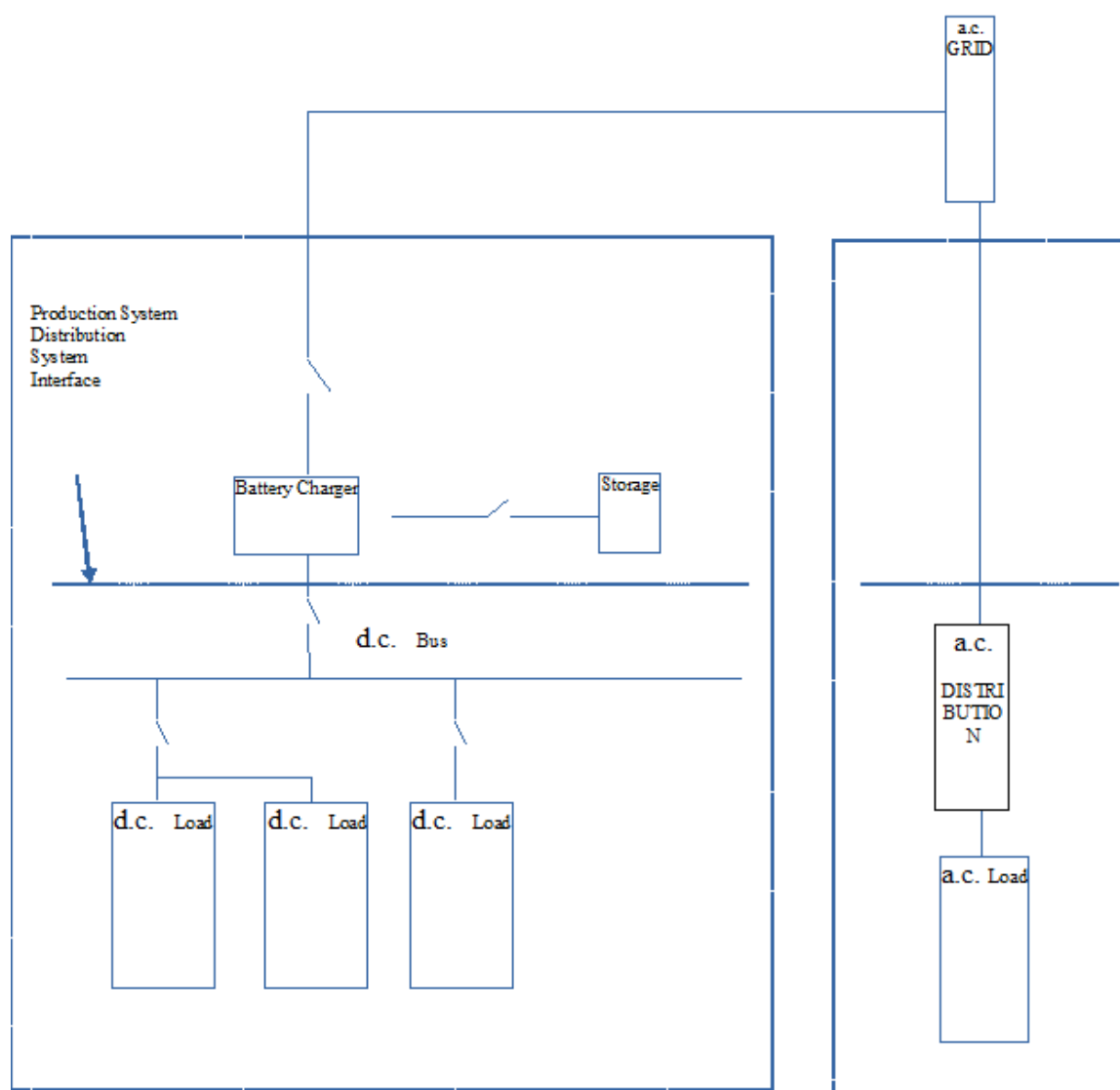


FIG. 4 SCENARIO WHERE d.c. IS DERIVED FROM THE GRID

requirements as given in IEC 60364-4-41:2005 shall apply.

5.3 Protection Against Overcurrent

5.3.1 Each branch circuit should be protected with a 5A rated fuse or equivalent MCB. IEC 60269-2 provides conventional time and current for 'gG' fuse-links with current less than 16A. IEC 60269-2 is generally envisaged for use in applications where the voltages are much higher than 48V required by this standard, but there is no loss of generality by using the standard for 48V d.c. The time-current zones for 'gG' fuse-link for low-voltage fuses is given in IEC 60269-2 (see Fig. 6) and reproduced in Table 3 and Table 4 for reference.

5.3.2 The feeder should be protected with a 'gG' d.c. fuse

rating with a rating that depends on the number of branch circuits. For n branch circuits, the rating shall be $4n$. For instance, if there are 10 branch circuits in an installation, the rating of the fuse on the main branch shall be 40A. In

Table 3 Conventional Time and Current for 'gG' Fuse-links with Rated Current Lower than 16 A
(Clause 5.3)

SI No	Rated Current, I_n A	Conventional Time h	Conventional Current	
			I_{nf}	I_f
(1)	(2)	(3)	(4)	(5)
i)	$I_n \leq 4$	1	$1.5 I_n$	$2.1 I_n$
ii)	$4 < I_n < 16$	1	$1.5 I_n$	$1.9 I_n$

NOTE — Table 3, excerpted from IEC 60269-2 provides the basis for fuses to be used in this standard

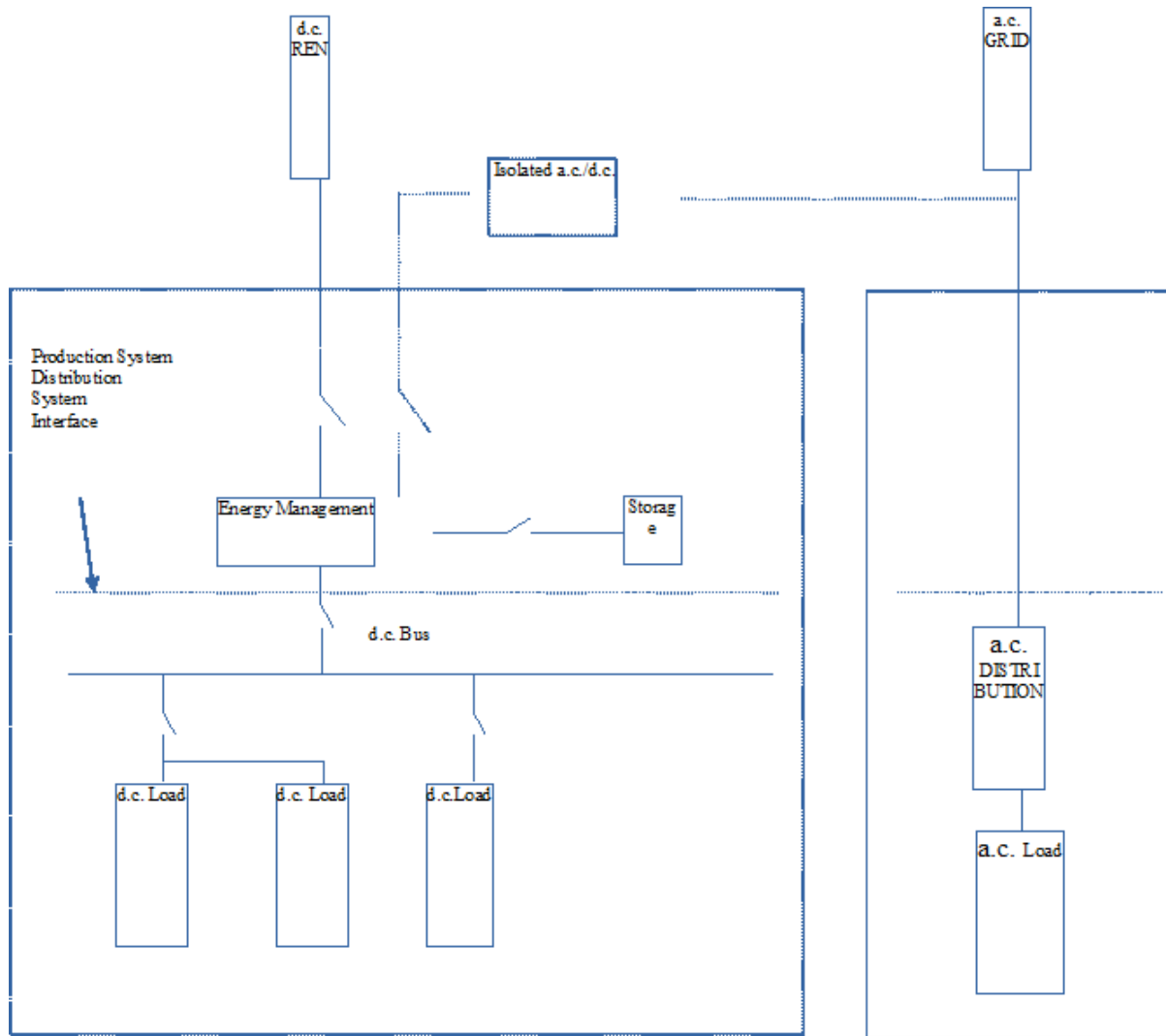


FIG. 5 SCENARIO WHERE a.c. AND d.c. DISTRIBUTION SYSTEMS CO-EXIST, BUT d.c. IS GENERATED FROM RENEWABLE SOURCES

Table 4 Gates for Specified Pre-arcing and Operating Times of ‘gG’ Fuse-links
(Clause 5.3)

Sl No.	I_n A	I_{min} (10s) A	I_{max} (5 s) A	I_{min} (0.1 s) A	I_{max} (0.1 s) A
(1)	(2)	(3)	(4)	(5)	(6)
i)	2	3.7	9.2	6.0	23.0
ii)	4	7.8	18.5	14.0	47.0
iii)	6	11.0	28.0	26.0	72.0

NOTE — Table 4, excerpted from IEC 60269-2 provides the basis for fuses to be used in this standard

the case of battery, ratings will depend on the feeder limit as well as the charging current limits. Circuit breakers for use at 48 V d.c. and with 5A currents is not standardised. Single phase a.c. mains circuit breakers can be used with appropriate derating may be used. The derating characteristics are yet to be standardised.

Protection against over-current and short-circuit shall meet IEC 60364-4-43.

5.4 Size of Distribution Conductors

The distribution conductor size for branch circuits shall be 1.5 mm², 2.5 mm² or 4 mm² depending on the power and distance. The feeder conductor size and battery conductor size will depend on the number of branches.

5.5 Conductor Colour Coding

The colours for the insulation on the conductors shall follow the recommendations given in IEC 60445 : 2017 ‘Basic and safety principles for man-machine interface, as reproduced in Table 5.

5.6 Distribution Boards and Enclosures

Standard panel (distribution boards) boards shall be

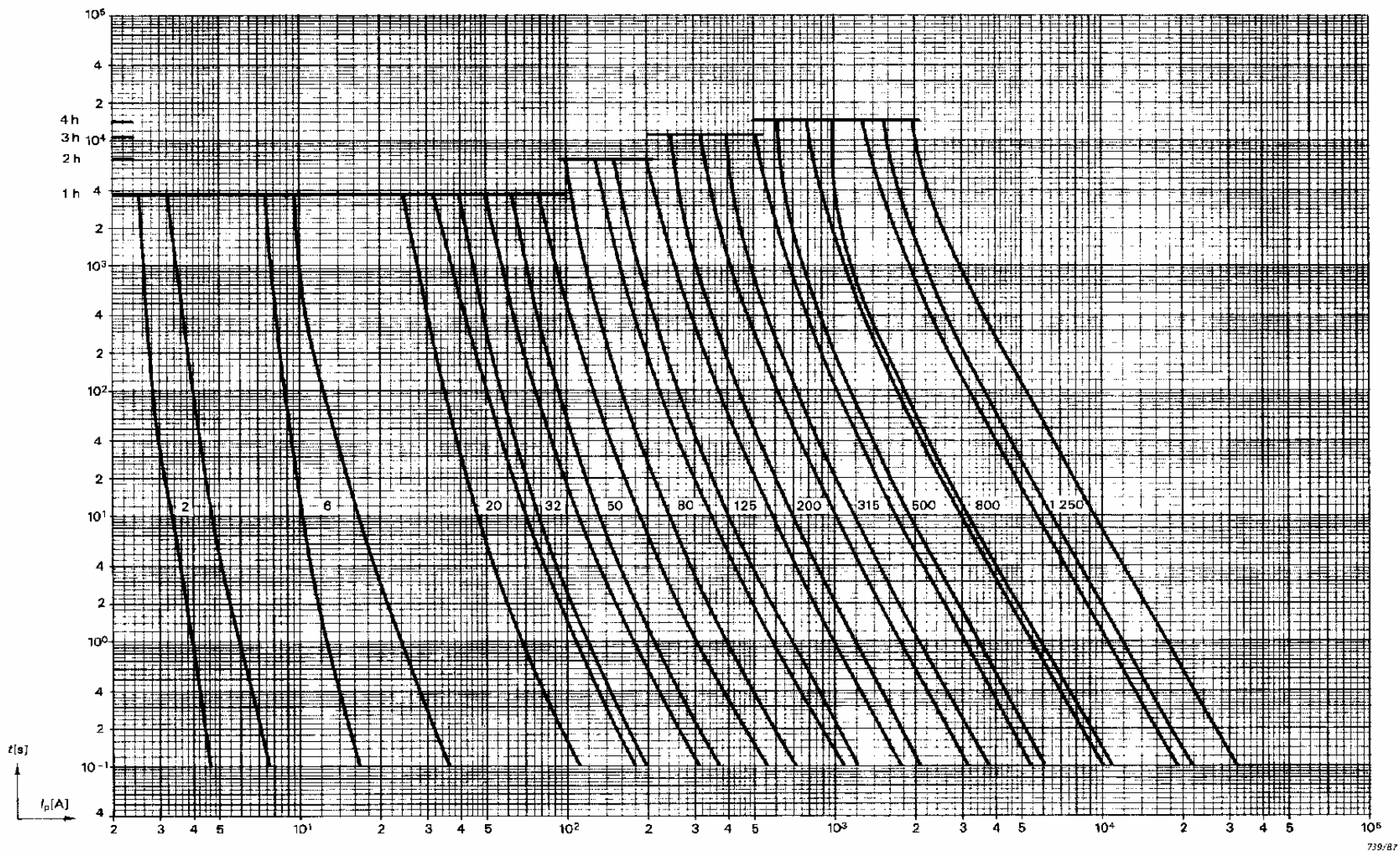


FIG. 6 TIME CURRENT ZONES FOR 'GG' FUSE LINKS

**Table 5 Colours, Alphanumeric Notations and Graphical Symbols
Used for Identification of Conductors and Terminals
(Clause 5.5)**

Sl No	Designated Conductors/Terminals	Identification of Conductors / Terminals by			
		Alphanumeric Notations a		Colours	Graphical Symbols b
(1)	(2)	Conductors	Terminals	(5)	(6)
i)	d.c. conductors	d.c.	d.c.	-	---
	a) Positive	L+	+	 RD(RED)	
	b) Negative	L-	-	 WH(WHITE)	
ii)	Protective conductor			 GNYE(bi-colour combination GREEN-AND-YELLOW).	
		PE	PE		

selected using to IEC 61439-3 as a guideline. Since the distribution voltage is below 60V, some of the protection aspects covered by the standard can be relaxed in the fabrication of panel boards for distribution.

5.7 Earthing

There is no requirement for earthing in a pure d.c. system. Exposed metal frames and exposed conducting parts of plugs, sockets, appliances can be left ungrounded. There is no need for over-voltage protection devices, except for lighting protection.

Earthing is needed wherever a.c. distribution exists. In the presence of a.c., the possibility of exposure to dangerous voltages is possible in the case of a single fault. In such scenarios, the earthing of exposed metal parts is needed to ensure that accidental contact of a.c. live wire with exposed metallic part on the d.c. system does not result in exposure to high a.c. voltages and results in tripping of the a.c. line. In such a case, exposed metallic parts of d.c. loads and distribution components, enclosures shall be earthed. The resulting distribution system is an IT system as described in IEC 60364-1.

5.8 Protection from Over Voltages of Atmospheric Origin or Due to Switching (Surge Protection)

Protection from surge voltages shall be provided with SPDs Surge Protection devices connected between each feeder line and earth shall be provided. In cases where distribution involves wiring from one premise to another through a branch circuit, SPDs shall be used at the entry to the premises which is fed by the branch circuit.

SPDs shall be chosen according to according to IEC 60364-4-44.

5.9 Over Voltage Protection Devices

Over Voltage protection devices between the positive

and negative conductor shall be used at each branch circuit if there is a possibility of high-impedance connection with a different higher voltage source like a.c. mains. These devices shall limit the voltage to less than 60 V between the positive and negative conductor in the case of a fault and provide a path to earth which shall trip a 30mA residual circuit device at the a.c. mains.

Over voltage protection is not required when there is no possibility of co-existence with other higher voltage systems like a.c. mains for example.

Over voltage protection devices shall be chosen according to IEC 61643-21.

5.10 Socket Outlets

The socket outlets shall exclude plugs of other voltage systems. The socket outlets shall be polarised such that positive and negative contacts cannot be interchanged.

Socket outlets shall not have a protective conductor connection.

NOTE — This is in accordance with IS 732.

Detailed specifications of plugs and sockets for ELVDC will be made available in a different standard under preparation.

5.11 Plugs

The plugs shall not be capable of entering socket outlets of other voltage systems. And exclude plugs of other voltage systems. Plugs shall be polarised such that positive and negative contacts cannot be interchanged while connected to a mating socket.

Plugs shall not have a protective conductor connection.

NOTE — Detailed specifications of plugs and sockets for

ELVDC will be made available in a different standard under preparation.

5.12 Terminations

Polarised terminals shall be used for termination of conductors in a branch circuit. An appliance or equipment connected to these terminations shall have a similar polarised connector so that accidental polarity reversal is not possible. Branch circuits terminating in Socket Outlets shall also have polarised terminals.

NOTE — Detailed specifications of Terminations for ELVDC will be made available in a different standard under preparation

5.13 Clearance and Creepage

Clearances, creepage distances and distances through insulation (for prevention of arcing, fire and high temperature). The minimum clearance shall be 0.2 mm for functional insulation, 0.4 mm for basic insulation and 0.8 mm for reinforced insulation as given in IS 13252 (Part 1).

5.13.1 Pollution Degrees

Pollution degrees are classified as follows:

- a) Pollution Degree 1, applies where there is no pollution or only dry, non-conductive pollution. The pollution has no influence on the behaviour of the circuit, either functionally or through aging. Normally, such an environment is achieved by having components and subassemblies adequately enclosed by enveloping or hermetic sealing so as to exclude dust and moisture.
- b) Pollution Degree 2, applies where there is only non-conductive pollution that might temporarily become conductive due to occasional condensation. Minimum creepage distances on PCB shall be 0.04 mm for Pollution Degree 1 and 0.063 mm for Pollution Degree 2 as given in IS 13252 (Part 1).

5.14 Disconnect Methods

A disconnect device or devices shall be provided to disconnect the main feeder line or branch circuit or equipment/ appliance for servicing.

A disconnect device shall have a contact separation at least equal to the minimum clearance for basic insulation.

Examples of disconnect devices that are permitted are:

- a) A circuit-breaker;
- b) An isolating switch;
- c) An appliance coupler;

- d) Plug on the power supply cord;
- e) Plug that is part of direct plug — in equipment;
- f) A removable fuse, provided that it is accessible only to a service person; and
- g) Any equivalent device:

5.15 Parts which Remain Energized

Parts on the supply side of a disconnect device in the equipment which remain energized when the disconnect device is switched off shall be guarded so as to reduce the likelihood of accidental contact by a service person.

5.16 Photovoltaic Panels and Arrays

The requirements, characteristics and installation shall be as given in IEC 62257-7-1.

5.17 Batteries

The requirements given in IEC 62257-8-1 available in developing countries shall apply.

Supply systems and equipment containing batteries shall be designed to reduce the risk of fire, explosion and chemical leaks under normal conditions and after a single fault in the equipment including a fault in circuitry within the equipment battery pack. For user-replaceable batteries, the design shall reduce the likelihood of reverse polarity installation if this would create a hazard.

Battery circuits shall be designed so that,

- a) the output characteristics of a battery charging circuit are compatible with its rechargeable battery;
- b) for non-rechargeable batteries, discharging at a rate exceeding the battery manufacturer's recommendations, and unintentional charging, are prevented;
- c) for rechargeable batteries, charging and discharging at a rate exceeding the battery manufacturer's recommendations, and reversed charging, are prevented; and
- d) operator-replaceable batteries shall either,
 - 1) have contacts that cannot be shorted with the test finger as given in IS 13252 (Part 1)
 - 2) be inherently protected to avoid creating a hazard within the meaning of the standard.

If a battery contains liquid or gel electrolyte, a battery tray shall be provided that is capable of retaining any liquid that could leak as a result of internal pressure build-up in the battery. The requirement to provide a battery tray does not apply, if the construction of the battery is such that leakage of the electrolyte from the battery is unlikely.

If a battery tray is required, its capacity shall be at least equal to the volume of electrolyte of all the cells of the battery, or the volume of a single cell if the design of the battery is such that imultaneous leakage from multiple cells is unlikely.

5.18 Battery Compartments

Access by an operator to bare conductive parts of circuits within a battery compartment in the equipment is permitted, if all of the following conditions are met:

- a) The compartment has a door that requires a deliberate technique to open, such as the use of a tool or latching device;
- b) There is a marking next to the door, or on the door if the door is secured to the equipment, with instructions for protection of the user once the door is opened; and
- c) The circuit is not accessible when the door is closed.

(Continued from second cover)

Table 1 Equipment Having a Nominal Voltage Below 120 V a.c. or Below 750 V d.c.

d.c.		a.c.	
Nominal Values		Nominal Values	
Preferred V	Supplementary V	Preferred V	Supplementary V
	2.4		
	3		
	4		
	4.5		
	5		5
6		6	
	7.5		
	9		
12		12	
	15		15
24		24	
	30		
36			36
	40		
48		48	
60			60
72			
	80		
96			
			100
110		110	
	125		
220			
	250		
440			
	600		

NOTE — Primary and secondary voltages for voltages less than 750V for d.c. and 120V for ac, as specified in IEC 60038 : 2009. Table excerpted from IEC 60038 : 2009 shows the numbering of the sections as given in the original document. This document provides the basis for 48V to be adopted for d.c. distribution. 48V is the highest voltage which is approved as a primary voltage for d.c. falls and yet falls under the non-hazardous voltage category (Hazardous Voltage defined in **1.2.8.6**, IS 13252 (Part 1)).

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: ETD 50 (11294).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002

Telephones : 2323 0131, 2323 3375, 2323 9402

Website: www.bis.org.in

Regional Offices:

Telephones

Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	{ 2323 7617 2323 3841
Eastern	: 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700054	{ 2337 8499, 2337 8561 2337 8626, 2337 9120
Northern	: Plot No. 4-A, Sector 27-B, Madhya Marg, CHANDIGARH 160019	{ 26 50206 265 0290
Southern	: C.I.T. Campus, IV Cross Road, CHENNAI 600113	{ 2254 1216, 2254 1442 2254 2519, 2254 2315
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	{ 2832 9295, 2832 7858 2832 7891, 2832 7892

Branches: AHMEDABAD. BENGALURU. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. DURGAPUR. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. JAMMU. JAMSHEDPUR. KOCHI. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAIPUR. RAJKOT. VISAKHAPATNAM.

Published by BIS, New Delhi